


## Silent But Deadly, The Elusive Pulmonary Embolus

*Susan Dresser RN MSN ACNS-BC CCRN  
Education Consultant  
Deaconess Hospital Oklahoma City, Ok.*



### what happened?



- 5 weeks of bedrest.
- The cord was around our baby's neck.
- Her heart rate dropped (multiple times).
- Liz almost delivered (multiple times).
- the day finally came and madeline was born via c-section.
- Liz was told to hang out in bed for a few hours.
- she waited patiently
- Finally she got ready to lay her hands on madeline for the very first time
- she got up from bed and walked to the mirror and said,
- "my hair looks like shit." we all laughed
- (her hair looked great for someone who'd been on bed rest for 5 weeks)
- "are you ready to go?" "yes!" her excitement overflowing
- she turned around to sit in her wheelchair for her ride to see madeline.
- "i feel lightheaded" and she passed out.
- doctors and nurses rushed to help her
- but nothing could be done
- to bring her back.
- no one to blame. shitty luck and a
- pulmonary embolism are what led us to the saddest,
- most horrific moment of my life.






### David Bloom 1963 - 2003 Respected NBC Reporter Dies in Iraq

*"All too often, patients die of PE without ever knowing they had it. The condition is difficult to detect because it is often "silent", presenting no obvious signs or symptoms"*

Victor Tapson, MD Duke University Medical Center






### A Diagnosis That Is Easy To Overlook

- Thousands suffer from deep vein thrombosis (DVT) in the United States today, and many will die from its complication, pulmonary embolism (PE).
- The tragedy of this disease is that the diagnosis is easy to overlook because the signs and symptoms are often diffuse and difficult to recognize.


### A Diagnosis That is easy to overlook

- ❑ Perhaps as many as 50-80% percent of the cases of DVT are "silent" or asymptomatic
- ❑ 70% of PE undetected until postmortem examination is performed after sudden death.
- Often the first symptom of DVT is a fatal PE



### Definition

- VTE- Venous thromboembolism encompasses superficial and deep vein thrombosis (DVT) and pulmonary embolism (PE)
- All part of the same physiologic process.



### VTE: Magnitude of the Problem

- Annual incidence of VTE in the US:
- Approximately 600,000-900,000 cases of VTE <sup>1,2,5,6</sup>
- Estimated 200,000- 300,000 deaths due to DVT/PE <sup>1,5</sup>
  - 7% treated, 34% sudden and fatal, 59% undetected <sup>6</sup>
- Annual number at risk for VTE in US hospitals:
  - 7.7 million medical service inpatients <sup>3</sup> } 31% of hospital discharges
  - 4.3 million surgical service inpatients <sup>3</sup> }
- 2/3 of VTE cases and deaths are hospital-acquired <sup>1</sup>

1. US Department of Health and Human Services. The Surgeon General's Call To Action to Prevent DVT and PE. Bethesda, MD. September 2008  
 2. Anderson FA Jr, et al. Arch Intern Med. 1991;151 (5) 933-938  
 3. Anderson FA Jr, et al. Am J Hematol 2007;82(9) 777-782  
 4. Geerts WH, et al. Chest 2008;133:3815-4535  
 5. Leizorovic A, et al. Circulation. 2004, 110:874-879  
 6. Heit JA, Cohen AT, Anderson FA Jr, et al., Estimated annual number of incident and recurrent, non-fatal and fatal venous thromboembolism (VTE) events in the U.S., Blood (ASH Annual Meeting Abstracts), 2005;106:910.

### VTE: Magnitude of the Problem

- In fact PE is the third leading cause of hospital-related death in the United States.
- PE is the leading preventable cause of hospital death

Geerts,WH, et al. Chest 2008,133;3815-4535

### More deaths than AIDS, breast cancer, auto

Equals 1 jumbo jet crash /day



Surgeon General's Call to Action to Prevent DVT and PE 2008 DHHHS

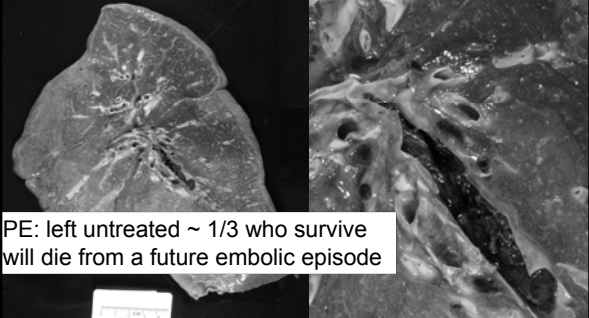
### The Burden of VTE

- In addition to risk of sudden death/ fatal PE
  - Increased hospital LOS, risk of stroke and MI
- Over a 5-10 year period increased risk of :
  - Recurrent VTE up to 30%
  - Post-thrombotic syndrome 20-30%
  - Pulmonary hypertension 1-5%

Goldhaber SZ. N Engl J Med. 1998;339:93-104.  
 Silverstein MD, et al. Arch Intern Med. 1998;158:585-593.  
 Heit JA, et al. Thromb Haemostas. 2001;86:452-463.  
 Heit JA. Clin Geriatr Med. 2001;17:71-92.  
 Heit JA, et al. Mayo Clin Proc. 2001;76:1102-1110.

### Pulmonary Embolism Defined

Mechanical obstruction of pulmonary vessels with an embolus



PE: left untreated ~ 1/3 who survive will die from a future embolic episode

### Massive PE – Life Threatening

Presentation: sudden onset catastrophic hemodynamic collapse  
 Others may suffer stuttering progressive clinical deterioration  
 Criteria: Hypotension and cardiogenic shock

↓ SBP < 90 mmHG or ↓ 40 mmHg for 15 minutes	↓ Tissue hypoperfusion Hypoxia Altered LOC Oliguria, cool, clammy
--	--

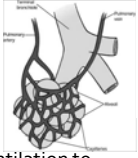


### Pathophysiology

#### Arterial Hypoxemia

- V/Q mismatch (ventilation and perfusion)
  - Low V/Q ratio in some gas exchange units
  - High V/Q ratio in others
- Atelectasis due to
  - Loss of surfactant
  - Alveolar hemorrhage
- R to L shunting occurs when there is no ventilation to perfused lung units or when venous blood enters the systemic circulation without passing through ventilated gas exchange units
- Failure to correct hypoxemia despite high  $F_iO_2$ 
  - Huge R → L shunt (heart/lungs/both)


Low cardiac output – increased tissue extraction of  $O_2$



### Signs in Massive P.E.

- “Massive PE”: hemodynamic instability with SBP <90 or a drop in baseline SBP by  $\geq 40$  mmHg
- Profound dyspnea at rest
- Anxiety
- Syncope
- Lightheadedness
  - Acute right heart failure
    - Elevated J.V.P.
    - Right-sided  $S_3$
    - Parasternal lift

### Risk Factors for VTE



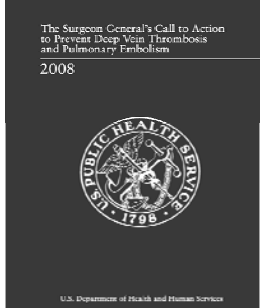
**Most hospitalized patients have at least one risk factor for VTE**

- Stasis
- Age > 40
- Immobilization
- CHF
- Stroke
- Paralysis
- Spinal Cord injury
- Hyperviscosity
- Polycythemia
- Severe Trauma
- Anesthesia
- Obesity
- Varicose Veins
- Hypercoagulability
- Cancer
- Estrogen states
- Intestinal Syndrome
- Smoking
- Pregnancy
- Thrombophilia
- Surgery
- Prior VTE
- Central lines
- Trauma

Anderson FA Jr. & Wheeler HB. *Clin Chest Med* 1995;16:235.

### Surgeon General’s Call to Action Against DVT/PE

- “Must disseminate information widely” to “address gap” between clinical evidence and implementation. We are not applying knowledge systematically.”



Galson SK. <http://www.surgeongeneral.gov/topics/deepvein/calltoaction/call-to-action-on-dvt-2008.pdf>. Accessed October 2010.

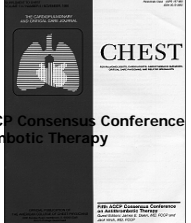
### VTE Prevention is on The Radar

- Leapfrog<sup>1</sup>: PE is “the most common preventable cause of hospital death in the United States”
- CMS, NQF & TJC aligned their quality performance measures
- Agency for Healthcare Research and Quality (AHRQ)<sup>2</sup>: Thromboprophylaxis is the number 1 patient safety practice
- Institute Of Medicine (IOM) classified failure to provide screening and prophylaxis as a medical error
- American Public Health Association (APHA)<sup>3</sup>: “The disconnect between evidence and execution as it relates to DVT prevention amounts to a public health crisis.”

- The Leapfrog Group Hospital Quality and Safety Survey. Available at: [www.leapfrog.medstat.com/pdf/Final/doc](http://www.leapfrog.medstat.com/pdf/Final/doc)
- Shojania KG, et al. Making Healthcare Safer: A Critical Analysis of Patient Safety Practices. AHRQ, 2001. Available at: [www.ahrq.gov/clinic/ptsafety/](http://www.ahrq.gov/clinic/ptsafety/)
- White Paper. Deep-vein thrombosis: Advancing awareness to protect patient lives. 2003. Available at: [www.alpha.org/ppp/DVT\\_White\\_Paper.pdf](http://www.alpha.org/ppp/DVT_White_Paper.pdf)

### ACCP VTE Prophylaxis Guidelines 8<sup>th</sup> Edition

- Every hospital should develop a formal VTE prophylaxis policy
- Do not use aspirin alone as prophylaxis for any patient group
- Mechanical prophylaxis primarily for patients at high bleeding risk
- Group specific prophylaxis rather than individual
- Give thromboprophylaxis for
  - Major trauma
  - Spinal cord injury
  - Acute medical illness
  - Most ICU patients



Geerts WH, et al. *Chest*. 2008;133:381S-453S.

VTE Levels of Risk		
Levels of Risk	DVT Risk Without Prophylaxis	Suggested Options
<b>Low risk</b> • Mobile minor surgery patients • Fully mobile medical patients	< 10%	• No specific thromboprophylaxis • Early and "aggressive" ambulation
<b>Moderate risk</b> • Most general, open gynecologic or urologic surgery • Medical patients, bed rest or sick • CHF • COPD, pneumonia	10-40%	• LMWH, UFH bid or tid, fondaparinux • Mechanical prophylaxis if risk of bleeding is high
<b>High risk</b> • Hip or knee arthroplasty, HFS • Major trauma, SCI • Abdominal/pelvic cancer surgery	40-80%	• LMWH, fondaparinux, VKA (INR 2-3) • Mechanical prophylaxis may be used if risk of bleeding is high; switch to anticoagulants when risk decreases

Adapted from Geerts WH, et al. Chest. 2008;133:381S-453S.

Prevention of Venous Thromboembolism <i>Low-, moderate-, or high-risk</i>		
Benefit: risk favors routine prophylaxis	Benefit: risk uncertain- <u>local practice</u> or individual prophyl.	Benefit: risk favors no prophylaxis
<b>Focus of New Measures</b> • Major orthopedic surgery (THR, TKR, HFS) • Major trauma • Spinal cord injury • Major general, gyne, urologic surgery • Major neurosurgery • Medical patients with additional risk factors • Most ICU patients	• Laparoscopic surgery • Vascular surgery • Cardiac surgery • Elective spine surgery • Arthroscopic surgery • Burns • Isolated lower extremity fracture	• Surgical patients: - brief duration - fully mobile - no additional RFs • Medical patients: - fully mobile - no additional RFs • Long distance travel <div style="border: 1px solid black; padding: 2px; margin-top: 5px;"> <i>How many of these patients do we actually admit to the hospital anymore?</i> </div>

VTE Prophylaxis Options	
<ul style="list-style-type: none"> <li>▪ Pharmacologic</li> <li>▪ Unfractionated heparin</li> <li>▪ Warfarin</li> <li>▪ LMWH</li> <li>▪ Xa inhibitors</li> <li>▪ Oral thrombin inhibitors</li> <li>▪ (ASA)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Mechanical</li> <li>▪ Early ambulation</li> <li>▪ Graded elastic stockings</li> <li>▪ Intermittent pneumatic compression (IPC)</li> <li>▪ IVC filters</li> </ul>

**Early administration of parental anticoagulation is the most effective and safe method to prevent the onset of thrombosis in at risk patients and to prevent extension and embolization in those with established thrombosis ACCP 2007**

Both unfractionated heparin (UFH) and low-molecular weight heparin (LMWH) can be utilized safely for prevention and treatment of VTE

**Is VTE Prophylaxis Effective?**

Meta-Analysis  
Anticoagulant VTE prophylaxis in 19,958 at-risk hospitalized medical patients in 9 studies

↓

62% reduction in fatal PE  
 57% reduction in fatal or nonfatal PE  
 53% reduction in DVT  
 Nonsignificant increase in bleeding

Dentali et al. Ann Intern Med; 2007;146:278-288

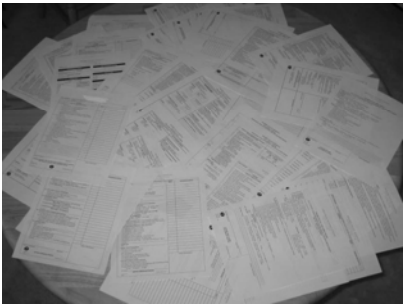
**Is the campaign to prevent VTE in hospitalized patients working??**

### Prophylaxis Is Underused !

- Patients with risk factors for VTE can be identified
- Effective strategies are available to prevent deep vein thrombosis and pulmonary embolism
- However, despite ongoing research to discover and refine the best approaches to prevention and care, the problem persists without marked improvement.

### Why ?

### Prophylaxis Is Underused !



### Registry Data

*Highlight the Underuse of Thromboprophylaxis*

DVT-FREE      RIETE      IMPROVE


↓                      ↓                      ↓

**BAD NEWS!**  
**Only a minority of hospitalized patients receive thromboprophylaxis**

Goldhaber SZ, Tapson VF. Am J Cardiol 2004;93:259-62.  
 Monreal M, et al. J Thromb Haemost 2004;2:1892-8.  
 Tapson V, et al. Blood 2004;104:11. Abstract #1762.

### ENDORSE : WORLDWIDE

(Lancet 2008; 371: 387-394)



**68,183 patients; 32 countries; 358 sites**  
 First patient enrolled August 2, 2006; Last patient enrolled January 4, 2007

### Worldwide Prophylaxis Status for 68,183 Patients

52% at Risk for VTE  
 (50% receive ACCP recommended prophylaxis)

**Surgical**                      **Medical**

64% at Risk for VTE                      42% at Risk for VTE

↓    ↓


59% receive ACCP Rec. Px                      40% receive ACCP Rec. Px

### 1979-2006 (# patients discharged with DVT or PE)

PATIENTS ADMITTED WITH DX DVT OR PE (PRINCIPAL DX)	PATIENTS DEVELOPED DVT/PE DURING HOSPITALIZATION
<ul style="list-style-type: none"> <li>1979-1989 18% drop in incidence of DVT</li> <li>1989-2006 No change in incidence of principal DVT</li> <li>1979-1992: incidence of PE principal dx decreased</li> </ul>	<ul style="list-style-type: none"> <li>1989-2006 : a 3.1 increase in incidence of secondary dx DVT</li> <li>1979-1992- incidence of PE secondary dx decreased</li> </ul>

### Diagnosis: To diagnose PE, one must think of PE as a diagnostic possibility

### Diagnosis



- First, have a high clinical suspicion of PE.-
- Based on history, analysis of risk factors for VTE, symptoms, signs
- Once the clinical suspicion exists, a clinical pre-test probability can be carried out using standardized scoring system: Wells and Geneva being two frequently used.

### Pulmonary Embolism: Modified Wells' criteria

[Ann Intern Med 2001; 135: 98 - 107]

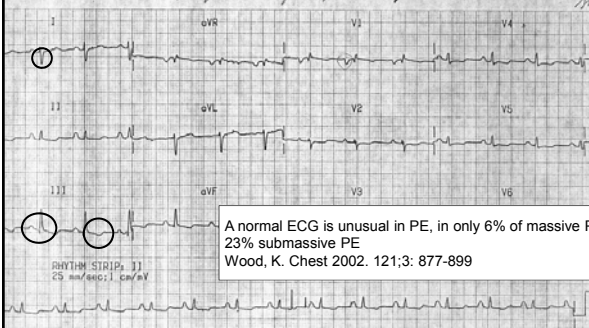
Clinical findings suggestive of DVT:	3
• No other more likely alternative diagnosis:	3
• Immobilization (bedridden <sup>3</sup> 3 days) or major surgery within past 4 wks:	1.5
• HR > 100:	1.5
• Previous DVT/PE:	1.5
• Active malignancy:	1
• Hemoptysis:	1
Is the score...	
A. Greater than 4? PE Likely	Risk Points
B. Less than 4? PE Unlikely	Low 0-2
	Moderate 3-6
	High >6

### Lab & Radiologic Findings in P.E.

- ABG
- BNP
- Cardiac Enzymes: Troponin
- D-dimer
- EKG
- CXR
- Ultrasound
- V/Q Scan
- Angiography
- CT scan

80yo pt. on meds had #Hot(58):  
 Echo showed >RA, >RV, TR cor pulmonale  
 secondary polycythemia was **S1Q3T3!!** PE: S1, Q5T3

P pulmonale  
 S, T3, Q3 → pathognomonic for pulmo HTN/PE



A normal ECG is unusual in PE, in only 6% of massive PE  
 23% submassive PE  
 Wood, K. Chest 2002. 121:3: 877-899

### Lab Findings in P.E. (ABG)

- **ABG:**
  - Hypoxemia-is not uniform ( $\text{PaO}_2 > 80\text{mmHg}$  in 12-19% of patients) PLOPED
  - A normal  $\text{PaO}_2$  does not exclude PE (14% normal in PLOPED)
  - Hypocapnia (low  $\text{CO}_2$ )
  - Respiratory Alkalosis
  - 38% of patients without CPD and with angiographically proven PE had  $\text{PaO}_2$  and  $\text{PaCO}_2$  values that were **not low**

### Lab Findings in P.E. (D-dimer)

- **D-dimer:**
  - Degredation product of fibrin
  - $>500$  is abnormal
  - Sensitivity: High, 95% of PE pts will be positive
  - Specificity: Low
  - Normal – High Negative Predictive Value

### PE – Use of D-Dimer

- ▶ Not helpful when positive, but sensitive assay can exclude PE in low risk patient
- ▶ In patients with high pretest probability (ie massive PE) testing wastes valuable time
- ▶ Patients judged to be high risk for PE would still have a posttest PE probability of 5-20% even after negative ELISA and require further testing

Roy PM, Colombet I, Durieux R, et al. Systematic review and meta-analysis of strategies for the diagnosis of suspected pulmonary embolism. BMJ. 2005;331(7511):259

### Echocardiography

- Bedside TTE
- Enormously useful
- Readily available and repeatable
- Useful in the recognition of PE
- Capable of assessing severity of PE
- Estimate RV function
- RV hypokinesis- associated with higher mortality in patients with PE.
- Increased right ventricle size

### Lab Findings in P.E. (BNP)

- **BNP (beta natriuretic peptide)**
  - Insensitive test
  - Patient's with PE have higher levels than pts without, but not ALL patients with PE have high BNP
  - **Good prognostic value measure:** if **BNP  $>90$**  associated with adverse clinical outcomes (death, CPR, mechanical vent, pressure support, thrombolysis, embolectomy)

### Lab Findings in P.E. (Troponin)

- **Troponin**
  - High in 30-50% of pts with mod to large PE
  - Prognostic value if combined pro-NT BNP
    - Trop I  $>0.07$  + NT-proBNP  $>600$  = high 40 day mortality

## Lab Findings in P.E. (cont'd)

### ■ EKG

1. A normal ECG is unusual (reported in 14-30% of patients without CPD, 6% of massive PE, 23% submassive PE)
2. Rhythm disturbances are uncommon
3. ECG abnormalities are transient
4. 2 Most Common finding on EKG:
  - Nonspecific ST-segment and T-wave changes (45%)
  - Sinus Tachycardia

Historical abnormality suggestive of massive PE:

- S1Q3T3
- Right ventricular strain
- New RBBB
- RAD

## Spiral CT

- Major advantage of Spiral CT is speed:
  - Often the patient can hold their breath for the entire study, reducing motion artifacts.
  - Allows for more optimal use of intravenous contrast enhancement.
  - Spiral CT is quicker than the equivalent conventional CT permitting the use of higher resolution acquisitions in the same study time.
- Contraindicated in cases of renal disease.
- Sensitive for PE in the proximal pulmonary arteries, but less so in the distal segments.

## PE – Helical CT (CTA)

- ▶ Eng performed a systematic review (SR) of all studies & SRs on CTA prior to 2003
  - Only 1/6 SRs and 3/8 primary studies found CTA >90% sensitive for PE
- ▶ In a similar SR in 2005 Roy concluded
  - Negative CTA could safely exclude PE in low risk patients
  - Negative LE US plus negative CTA could exclude PE in moderate risk patients
- ▶ At the time of those SRs no studies of faster multidetector CTA (MDCT) were available

Eng J, Krishnan JA, Segal JB, et al. AJR 2004;183(6):1819-27. Roy PM, Colombet I, Durieux P, et al. BMJ 2005;331(7511):259.

## CT Angiogram

- Computed tomographic pulmonary angiography is the preferred as the first-line test for PE by both professional societies<sup>6</sup> and practicing physicians.

## Radiology Findings in P.E. (cont'd)

### CT Pulmonary Angiography (CT-PA)

- Widely used
- Institution dependent
- Sensitivity (83%)
- Specificity (96%): if negative, very low likelihood that pt has P.E.

## Pulmonary angiogram

- Invasive
  - Positive angiogram provides 100% certainty that an obstruction exists in the pulmonary artery.
  - Negative angiogram provides > 90% certainty in the exclusion of PE.

### Initial Treatment of Acute PE

ACCP Conference on Antithrombotic and Thrombolytic Therapy

2008 Guidelines  
Chest 2008; 133: 454-545S

- 4.1.1. For patients with objectively confirmed PE, we recommend short-term treatment with
  - SC LMWH (Grade 1A),
  - IV UFH (Grade 1A),
  - monitored SC UFH (Grade 1A),
  - fixed-dose SC UFH (Grade 1A), or
  - SC fondaparinux (Grade 1A) rather than no such acute treatment.
- Patients with acute PE should also be routinely assessed for treatment with thrombolytic therapy.

### Initial Treatment of Acute PE

ACCP Conference on Antithrombotic and Thrombolytic Therapy

2008 Guidelines  
Chest 2008; 133: 454-545S

- 4.1.8. In patients with acute nonmassive PE: initial treatment with LMWH over IV UFH (Grade 1A).
- In patients with massive PE, in other situations where there is concern about SC absorption, or in patients for whom thrombolytic therapy is being considered or planned: IV UFH over SC LMWH, SC fondaparinux, or SC UFH (Grade 2C).

### Therapeutic Approaches To Management of PE

- Risk stratification is vital to optimize treatment
- Anticoagulants alone typically sufficient for low risk PE
- High risk PE requires more aggressive therapy eg thrombolysis, embolectomy

### PE : Components of Risk Stratification

1. Clinical evaluation – assessment of BP, HR, RR, and O<sub>2</sub> saturation
2. Measurement of 2 cardiac biomarkers – troponin and BNP
3. Echocardiogram to estimate RV function and PAP
4. Chest CT scan to evaluate RV and PE size

### Immediate Initial Management

- High dose unfractionated heparin
- (10,000 U bolus followed by continuous infusion )
- Resuscitate : Crystalloid versus pressors ?
- Most commonly volume to increase C.O.
- *Caution: too much –worsening RV wall stress, RV ischemia, worsening septal shift to L, and worsening LV filling.*
- Dopamine/dobutamine considered

### Thrombolysis

- TPA is an effective option in high-risk patients
- Shown to prevent death in patients with massive PE by prompting a marked reversal of RV failure and a rapid return to normal RV size and function.
- Serious bleeding risks
- Retrospective ICOPER analysis found no benefit for thrombolysis in patients with massive PE (did not reduce 90 day mortality rate or 90 day recurrent PE rate)

Kucher N, Rossi E, De Rosa M, Goldhaber SZ. Massive pulmonary embolism. *Circulation*. 2006;113(4):577-582.

### Embolectomy

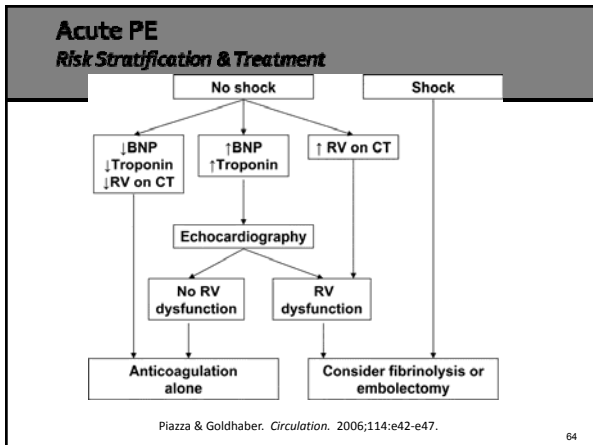
- Surgical removal of embolism
- May be pursued in patients at high risk of bleeding
- Performed either with a catheter or surgically
- Survival rates have been shown to be at 89%

### IVC Filter

- **Indication:**
  - Absolute contraindication to anticoagulation (i.e. active bleeding)
  - Recurrent PE during adequate anticoagulation
  - Complication of anticoagulation (severe bleeding)
- Also:
  - Pts with poor cardiopulmonary reserve
  - Recurrent P.E. will be fatal
  - Patient's who have had embolectomy
  - Prophylaxis against P.E. in select patients (malignancy)

### Anticoagulation (cont'd)

- **COUMADIN:**
  - Start once acute anticoagulation achieved
  - Start with 5mg PO qday OR 10mg PO q day
  - If start with 10mg then achieve therapeutic INR 1.4 days sooner
  - Complications and morbidity no different in 5mg or 10mg start
  - Goal INR 2 to 3



### Summary

- VTE is a very important source of hospital acquired cost, mortality, and morbidity.
- Prophylaxis is effective, safe, and cost-effective
- Prophylaxis is underutilized
- Increasing scrutiny from multiple agencies
- Institutional prioritization and support needed.
- The high death rate from PE and the high frequency of undiagnosed PE causing "sudden cardiac death" emphasize the need for improved preventive efforts.

**Thank You !**